

Claims

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1. An ion detector for use in a mass spectrometer,
said ion detector comprising:

one or more microchannel plates, wherein in use
ions are received at an input surface of said one or
10 more microchannel plates and electrons are released from
an output surface of said one or more microchannel
plates; and

an anode having a surface upon which electrons are
received in use;

15 wherein said ion detector further comprises:

one or more electrodes and/or one or more magnetic
lenses which, in use, direct, guide or attract at least
some of said electrons released from said output surface
of said one or more microchannel plates onto said anode;
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wherein said output surface of said one or more
microchannel plates has a first area and said surface of
said anode has a second area, wherein said second area
is $\geq 5\%$ of said first area.

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2. An ion detector as claimed in claim 1, wherein said
one or more electrodes and/or said one or more magnetic
lenses are arranged between said one or more
microchannel plates and said anode.

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3. An ion detector as claimed in claim 1, wherein said
one or more electrodes and/or said one or more magnetic

lenses are arranged so as to surround at least a portion of said anode.

4. An ion detector as claimed in claim 1, wherein said
5 one or more magnetic lenses comprises one or more
electro-magnets and/or one or more permanent magnets.

5. An ion detector as claimed in claim 1, wherein said
anode is made from a non-magnetic material.
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6. An ion detector as claimed in claim 1, wherein said
anode is made from a soft (low coercivity) magnetic
material.

7. An ion detector as claimed in claim 1, wherein said
anode is made from a hard or permanent (high coercivity)
magnetic material.
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8. An ion detector as claimed in claim 1, wherein said
20 second area is 5-90% of said first area.

9. An ion detector as claimed in claim 8, wherein said
second area is $\leq 85\%$, $\leq 75\%$, $\leq 70\%$, $\leq 65\%$, $\leq 60\%$, $\leq 55\%$,
 $\leq 50\%$, $\leq 45\%$, $\leq 40\%$, $\leq 35\%$ or $\leq 30\%$ of said first area.
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10. An ion detector as claimed in claim 8, wherein said
second area is $\leq 25\%$, $\leq 20\%$, $\leq 15\%$, or $\leq 10\%$ of said
first area.

11. An ion detector as claimed in claim 8, wherein said
second area is $\geq 10\%$, $\geq 15\%$, $\geq 20\%$ or $\geq 25\%$ of said
first area.
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12. An ion detector as claimed in claim 8, wherein said second area is $\geq 30\%$, $\geq 35\%$, $\geq 40\%$, $\geq 45\%$, $\geq 50\%$, $\geq 55\%$, $\geq 60\%$, $\geq 65\%$, $\geq 70\%$, $\geq 75\%$, $\geq 80\%$ or $\geq 85\%$ of said first area.

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13. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more ring lenses.

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14. An ion detector as claimed in claim 1, wherein said one or more electrodes have a thickness selected from the group consisting of: (i) ≤ 1.5 mm; (ii) ≤ 1.0 mm; and (iii) ≤ 0.5 mm.

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15. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more Einzel lens arrangements comprising three or more electrodes.

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16. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more segmented rod sets.

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17. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more tubular electrodes.

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18. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise one or more quadrupole rod sets.

19. An ion detector as claimed in claim 1, wherein said one or more electrodes comprise a plurality of electrodes having apertures through which electrons are

transmitted in use, said apertures having substantially the same area.

20. An ion detector as claimed in claim 1, wherein said
5 one or more electrodes comprise a plurality of
electrodes having apertures through which electrons are
transmitted in use, said apertures becoming
progressively smaller or larger in a direction towards
said anode.

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21. An ion detector for use in a mass spectrometer,
said ion detector comprising:

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one or more microchannel plates, wherein in use
ions are received at an input surface of said one or
more microchannel plates and electrons are released from
an output surface of said one or more microchannel
plates; and

an anode having a surface upon which electrons are
received in use;

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wherein said ion detector further comprises:

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one or more electro-magnets and/or one or more
permanent magnets which, in use, direct or guide at
least some of said electrons released from said output
surface of said one or more microchannel plates onto
said anode.

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22. An ion detector for use in a mass spectrometer,
said ion detector comprising:

one or more microchannel plates, wherein in use
ions are received at an input surface of said one or
more microchannel plates and electrons are released from
an output surface of said one or more microchannel
plates; and

an anode having a surface upon which electrons are received in use;

wherein said ion detector further comprises:

a plurality of electrodes and/or one or more
5 magnetic lenses which, in use, direct, guide or attract
at least some of said electrons released from said
output surface of said one or more microchannel plates
onto said anode, wherein said output surface of said one
or more microchannel plates has a first area and said
10 surface of said anode has a second area.

23. An ion detector as claimed in claim 22, wherein
said plurality of electrodes and/or said one or more
magnetic lenses are arranged between said one or more
15 microchannel plates and said anode.

24. An ion detector as claimed in claim 22, wherein
said plurality of electrodes and/or said one or more
magnetic lenses are arranged so as to surround at least
20 a portion of said anode.

25. An ion detector as claimed in claim 22, wherein
said one or more magnetic lenses comprises one or more
electro-magnets and/or one or more permanent magnets.

26. An ion detector as claimed in claim 22, wherein
said anode is made from a non-magnetic material.

27. An ion detector as claimed in claim 22, wherein
30 said anode is made from a soft (low coercivity) magnetic
material.

28. An ion detector as claimed in claim 22, wherein said anode is made from a hard or permanent (high coercivity) magnetic material.

5 29. An ion detector as claimed in claim 22, wherein said second area is 5-90% of said first area.

30. An ion detector as claimed in claim 29, wherein said second area is $\leq 85\%$, $\leq 75\%$, $\leq 70\%$, $\leq 65\%$, $\leq 60\%$, $\leq 55\%$, $\leq 50\%$, $\leq 45\%$, $\leq 40\%$, $\leq 35\%$ or $\leq 30\%$ of said first area.

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31. An ion detector as claimed in claim 29, wherein said second area is $\leq 25\%$, $\leq 20\%$, $\leq 15\%$, or $\leq 10\%$ of said first area.

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32. An ion detector as claimed in claim 29, wherein said second area is $\geq 10\%$, $\geq 15\%$, $\geq 20\%$ or $\geq 25\%$ of said first area.

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33. An ion detector as claimed in claim 29, wherein said second area is $\geq 30\%$, $\geq 35\%$, $\geq 40\%$, $\geq 45\%$, $\geq 50\%$, $\geq 55\%$, $\geq 60\%$, $\geq 65\%$, $\geq 70\%$, $\geq 75\%$, $\geq 80\%$ or $\geq 85\%$ of said first area.

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34. An ion detector as claimed in claim 22, wherein said anode comprises a pin anode.

35. An ion detector as claimed in claim 22, wherein said plurality electrodes comprises a plurality of ring lenses.

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36. An ion detector as claimed in claim 22, wherein said plurality of electrodes each have a thickness selected from the group consisting of: (i) ≤ 1.5 mm; (ii) ≤ 1.0 mm; and (iii) ≤ 0.5 mm.

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37. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise one or more Einzel lens arrangements comprising three or more electrodes.

10 38. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise one or more segmented rod sets.

15 39. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise a plurality of tubular electrodes.

20 40. An ion detector as claimed in claim 22, wherein said plurality of electrodes comprise one or more quadrupole rod sets.

25 41. An ion detector as claimed in claim 22, wherein said plurality of electrodes have apertures through which electrons are transmitted in use, said apertures having substantially the same area.

30 42. An ion detector as claimed in claim 22, wherein said plurality of electrodes have apertures through which electrons are transmitted in use, said apertures becoming progressively smaller or larger in a direction towards said anode.

43. An ion detector as claimed in claim 1, wherein in use said output surface of said one or more microchannel plates is maintained at a first potential, said surface of said anode is maintained at a second potential and
5 said one or more of said electrodes and/or said one or more magnetic lenses are maintained at a third potential.

44. An ion detector as claimed in claim 43, wherein
10 said second potential is more positive than said first potential.

45. An ion detector as claimed in claim 44, wherein the potential difference between said surface of said anode and said output surface of said one or more microchannel
15 plates is selected from the group consisting of: (i) 0-50 V; (ii) 50-100 V; (iii) 100-150 V; (iv) 150-200 V; (v) 200-250 V; (vi) 250-300 V; (vii) 300-350 V; (viii) 350-400 V; (ix) 400-450 V; (x) 450-500 V; (xi) 500-550
20 V; (xii) 550-600 V; (xiii) 600-650 V; (xiv) 650-700 V; (xv) 700-750 V; (xvi) 750-800 V; (xvii) 800-850 V; (xviii) 850-900 V; (xix) 900-950 V; (xx) 950-1000 V; (xxi) 1.0-1.5 kV; (xxii) 1.5-2.0 kV; (xxiii) 2.0-2.5 kV; (xxiv) > 2.5 kV; and (xxv) < 10 kV.

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46. An ion detector as claimed in claim 43, wherein said third potential is substantially equal to said first and/or said second potential.

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47. An ion detector as claimed in claim 43, wherein said third potential is more positive than said first and/or said second potential.

250-300 V; (vii) 300-350 V; (viii) 350-400 V; (ix) 400-
450 V; (x) 450-500 V; (xi) 500-550 V; (xii) 550-600 V;
(xiii) 600-650 V; (xiv) 650-700 V; (xv) 700-750 V; (xvi)
750-800 V; (xvii) 800-850 V; (xviii) 850-900 V; (xix)
5 900-950 V; (xx) 950-1000 V; (xxi) 1.0-1.5 kV; (xxii)
1.5-2.0 kV; (xxiii) 2.0-2.5 kV; (xxiv) > 2.5 kV; and
(xxv) < 10 kV.

49. An ion detector as claimed in claim 43, wherein
10 said third potential is more negative than said first
and/or said second potential.

50. An ion detector as claimed in claim 43, wherein
said third potential is intermediate said first and
15 second potentials.

51. An ion detector as claimed in claim 1, wherein said
surface of said anode is arranged a distance x from the
output surface of said one or more microchannel plates
20 and wherein x is selected from the group consisting of:
(i) < 5 mm; (ii) 5-10 mm; (iii) 10-15 mm; (iv) 15-20 mm;
(v) 20-25 mm; and (vi) 25-30 mm mm.

52. An ion detector as claimed in claim 1, wherein said
25 surface of said anode is arranged a distance x from the
output surface and wherein x is selected from the group
consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50
mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii)
65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm.

53. An ion detector for use in a mass spectrometer,
30 said ion detector comprising:

one or more microchannel plates, wherein in use
ions are received at an input surface of said one or
more microchannel plates and electrons are released from
an output surface of said one or more microchannel
5 plates; and

an anode having a surface upon which electrons are
received in use;

wherein said surface of said anode is arranged a
distance x mm from said output surface and wherein x is
10 selected from the group consisting of: (i) 35-40 mm;
(ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60
mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and
(ix) > 75 mm; and wherein said output surface has a
first area and said surface of said anode has a second
15 area.

54. An ion detector as claimed in claim 53, wherein
said second area is 5-90% of said first area.

20 55. An ion detector as claimed in claim 54, wherein
said second area is $\leq 85\%$, $\leq 80\%$, $\leq 75\%$, $\leq 70\%$, $\leq 65\%$, \leq
 60% , $\leq 55\%$, $\leq 50\%$, $\leq 45\%$, $\leq 40\%$, $\leq 35\%$ or $\leq 30\%$ of said
first area.

25 56. An ion detector as claimed in claim 54, wherein
said second area is $\leq 25\%$, $\leq 20\%$, $\leq 15\%$ or $\leq 10\%$ of
said first area.

30 57. An ion detector as claimed in claim 54, wherein
said second area is $\geq 10\%$, $\geq 15\%$, $\geq 20\%$ or $\geq 25\%$, of
said first area.

58. An ion detector as claimed in claim 54, wherein said second area is $\geq 30\%$, $\geq 35\%$, $\geq 40\%$, $\geq 45\%$, $\geq 50\%$, $\geq 55\%$, $\geq 60\%$, $\geq 65\%$, $\geq 70\%$, $\geq 75\%$, $\geq 80\%$ or $\geq 85\%$.

5 59. An ion detector as claimed in claim 53, wherein said anode comprises a pin anode.

60. An ion detector for use in a mass spectrometer, said ion detector comprising:

10 one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from an output surface of said one or more microchannel plates, said output surface having a first area; and
15 an anode having a surface upon which electrons are received in use, wherein the surface of said anode has a second area;

wherein said second area is 5-25% of said first area.

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61. An ion detector as claimed in claim 60, wherein said second area is $\leq 20\%$, $\leq 15\%$ or $\leq 10\%$ of said first area.

25 62. An ion detector for use in a mass spectrometer, said ion detector comprising:

one or more microchannel plates, wherein in use ions are received at an input surface of said one or more microchannel plates and electrons are released from
30 an output surface of said one or more microchannel plates, said output surface having a first area; and

an anode having a surface upon which electrons are received in use, wherein the surface of said anode has a second area;

5 wherein said second area is 30-90% of said first area.

63. An ion detector as claimed in claim 62, wherein said second area is $\geq 30\%$, $\geq 35\%$, $\geq 40\%$, $\geq 45\%$, $\geq 50\%$, $\geq 55\%$, $\geq 60\%$, $\geq 65\%$, $\geq 70\%$, $\geq 75\%$, $\geq 80\%$ or $\geq 85\%$ of said
10 first area.

64. An ion detector as claimed in claim 60, wherein said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from
15 the group consisting of: (i) < 5 mm; (ii) 5-10 mm; (iii) 10-15 mm; (iv) 15-20 mm; (v) 20-25 mm; and (vi) 25-30 mm.

65. An ion detector as claimed in claim 60, wherein
20 said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from the group consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm.

25 66. An ion detector as claimed in claim 1, wherein electrons may be received across substantially the whole of said second area.

30 67. An ion detector as claimed in claim 1, wherein said anode comprises a first portion, a second portion and an electrically insulating layer provided between said

first and second portions, said first portion having a surface upon which electrons are received in use.

5 68. An ion detector as claimed in claim 67, wherein in use said first portion is maintained at a different DC potential to said second portion.

10 69. An ion detector as claimed in claim 67, wherein in use said first portion is maintained at substantially the same DC potential as said second portion.

70. An ion detector as claimed in claim 1, wherein said anode is substantially conical.

15 71. An ion detector as claimed in claim 70, further comprising a substantially conical screen surrounding at least a portion of said anode.

20 72. An ion detector as claimed in claim 1, wherein said anode has a capacitance selected from the group consisting of: (i) 0.01-0.1 pF; (ii) 0.1-1 pF; (iii) 1-10 pF; and (iv) 10-100 pF.

25 73. An ion detector as claimed in claim 1, wherein said surface of said anode upon which electrons are received in use is substantially flat.

30 74. A mass spectrometer comprising an ion detector as claimed in claim 1.

75. A mass spectrometer as claimed in claim 74, wherein said ion detector is arranged in a Time of Flight mass analyser.

76. A mass spectrometer as claimed in claim 75, wherein said Time of Flight mass analyser comprises an axial Time of Flight mass analyser.

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77. A mass spectrometer as claimed in claim 75, wherein said Time of Flight mass analyser comprises an orthogonal acceleration Time of Flight mass analyser.

10 78. A mass spectrometer as claimed in claim 75, wherein said Time of Flight mass analyser further comprises a reflectron.

79. A mass spectrometer as claimed claim 74, further comprising an Analogue to Digital Converter ("ADC") connected to said ion detector.

15 80. A mass spectrometer as claimed in claim 74, further comprising a Time to Digital Converter ("TDC") connected to said ion detector.

20 81. A mass spectrometer as claimed in claim 74, further comprising an ion source selected from the group consisting of: (i) an Atmospheric Pressure Chemical Ionisation ("APCI") ion source; (ii) an Atmospheric Pressure Photo Ionisation ("APPI") ion source; (iii) a Laser Desorption Ionisation ("LDI") ion source; (iv) an Inductively Coupled Plasma ("ICP") ion source; (v) a Fast Atom Bombardment ("FAB") ion source; (vi) a Liquid
25 Secondary Ion Mass Spectrometry ("LSIMS") ion source; (vii) a Field Ionisation ("FI") ion source; (viii) a Field Desorption ("FD") ion source; (ix) an Electron
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Impact ("EI") ion source; and (x) a Chemical Ionisation ("CI") ion source.

5 82. A mass spectrometer as claimed in claim 74, further comprising a Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source.

10 83. A mass spectrometer as claimed in claim 74, further comprising an Electrospray ion source.

84. A mass spectrometer as claimed in claim 81, wherein said ion source is continuous.

15 85. A mass spectrometer as claimed in claim 81, wherein said ion source is pulsed.

86. A method of detecting ions comprising:
receiving ions at an input surface of one or more microchannel plates;
20 releasing electrons from an output surface of said one or more microchannel plates; and
directing, guiding or attracting at least some of said electrons released from said one or more microchannel plates onto a surface of an anode by means
25 of one or more electrodes and/or one or more magnetic lenses, wherein the area of said surface of said anode is $\geq 5\%$ of the area of said output surface of said one or more microchannel plates.

30 87. A method of detecting ions comprising:
receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing or guiding at least some of said electrons released from said one or more microchannel plates onto a surface of an anode by means of one or more electro-magnets and/or one or more permanent magnets.

88. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates;

directing, guiding or attracting at least some of said electrons released from said one or more microchannel plates onto a surface of an anode by means of a plurality of electrodes and/or one or more magnetic lenses.

89. A method of detecting ions comprising:

receiving ions at an input surface of one or more microchannel plates;

releasing electrons from an output surface of said one or more microchannel plates; and

directing at least some of said electrons released from said one or more microchannel plates onto a surface of an anode, wherein said surface of said anode is arranged a distance x mm from said output surface and wherein x is selected from the group consisting of: (i) 35-40 mm; (ii) 40-45 mm; (iii) 45-50 mm; (iv) 50-55 mm; (v) 55-60 mm; (vi) 60-65 mm; (vii) 65-70 mm; (viii) 70-75 mm; and (ix) > 75 mm.

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90. A method of detecting ions comprising:

receiving ions at an input surface of one or more
microchannel plates;

releasing electrons from an output surface of said
5 one or more microchannel plates; and

directing at least some of said electrons released
from said one or more microchannel plates onto a surface
of an anode, wherein the area of said surface of said
anode is 5-25% of the area of said output surface of
10 said one or more microchannel plates.

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91. A method of detecting ions comprising:

receiving ions at an input surface of one or more
microchannel plates;

15 releasing electrons from an output surface of said
one or more microchannel plates; and

directing at least some of said electrons released
from said one or more microchannel plates onto a surface
of an anode, wherein the area of said surface of said
20 anode is 30-90% of the area of said output surface of
said one or more microchannel plates.

92. A method of mass spectrometry comprising a method
of detecting ions as claimed in claim 86.